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Report on Research Into the Ability of a Top-Down Model To Accurately Estimate City Carrier Street Time Variabilities

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A. Preliminary Matters

In Order No. 2792 (Oct. 29, 2015), the Commission directed the Postal Service to investigate whether a single “top-down” model of city carrier street time could produce improved variability estimates:[1]

> To improve the quality, accuracy, and completeness of the data used to attribute city carrier street time costs, the Commission directs the Postal Service to collect the information needed to determine whether a single model could produce improved estimates of variability.

The Postal Service shares the Commission’s desire to be able to produce city carrier street time variabilities without the need for expensive, time consuming, special studies. In addition, the Postal Service is interested in investigating whether a top-down model could reliably produce the required variabilities. Consequently, the Postal Service developed and implemented a research plan to pursue the Commission’s directive. Such a research program has three steps, which must be performed seriatim. The three steps are:

- Explore the steps required to capture accurate daily letter route volumes of collection mail, in-receptacle parcels, deviation parcels, and accountable mail.
- Investigate if the obtained data would be sufficient to estimate a single equation model of total street time variability.
- If so, determine if a single model produces improved estimates of variability.

[1] See, Order No. 2792 (Oct. 29, 2015) at 65.

Of course, data must be obtained before an equation can be estimated, and the Postal Service investigated its various city carrier operational data systems, including the route evaluation system (Form 3999), the Collection Point Management System (CPMS), and the Product Tracking and Reporting (PTR) system, to identify sources of reliable data. After completing this investigation of possible sources of data, the Postal Service provided a description of the results of that research in its response to Chairman's Information Request No. 1 in Docket No. PI2017-1. In sum, the Postal Service determined that its Product Tracking and Reporting (PTR) holds the potential to provide reliable daily volumes for both parcels and accountables and, quite possibly, provide the split between in-receptacle and deviation parcels.[2] In contrast, the Postal Service found that there is no operational source for the volumes of mail collected from customer receptacles, that there is no acceptable proxy variable for these volumes, and that to incorporate collection of such volume information as part of its regular data collection process would be prohibitively expensive.[3] Consequently, the acquisition of volumes of mail collected by city carriers from customers' receptacles will require a special field study or a special application of the carriers' Mobile Delivery Devices (MDDs).[4]

[2] See, Responses of the United States Postal Service to Questions 1-7 of Chairman's Information Request No. 1, Docket No. PI2017-1, June 30, 2017 at Question 1.

[3] See, Response of the United States Postal Service to Commission Order 2792, Docket No. RM 2015-7, February 16, 2016 at 12 and Responses of the United States Postal Service to Questions 1-7 of Chairman's Information Request No. 1, Docket No. PI2017-1, June 30, 2017 at Question 2.

[4] See, Responses of the United States Postal Service to Questions 1-10 of Chairman's Information Request No. 2, Docket No. PI2017-1, July 25, 2017 at Question 2b.

In addition, the Postal Service investigated the feasibility of collecting the data necessary to estimate a top-down model through its route inspection (Form 3999) process. Unfortunately, the Form 3999 data set does not currently include any volumes for in-receptacle parcels, accountables, or volumes collected from customers' receptacles. In addition the Form 3999 does not independently measure volumes; rather, it imports volumes from DOIS, so adding a volume collection effort to the Form 3999 process would significantly change the route evaluation process and significantly increase the resources required to do so. To the extent the route evaluation process would begin to incorporate more detailed parcel and accountable data, those data would likely come from PTR, so it is appropriate to go to that system directly to obtain the needed parcel and accountable data. Moreover, there are potential issues with the vintages of Form 3999 data that do not exist with data extracted from the PTR system. In sum, the Form 3999 materials do not provide sufficient data to reliably estimate a top-down model of city carrier street time.

This report discusses the second step in the research process, investigating whether the data obtained from the Postal Service's operational data systems are sufficient to estimate a top-down single equation of city carrier street time. An immediate concern that arose in pursuing this effort is the fact that data on volumes collected by city carriers from customers' receptacles are not available. As explained in the Postal Service's response to Commission Order 2792, this omission precludes accurate estimation of a full top-down equation.[5] Thus, the Postal Service faced a decision as to

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[5] See, Response of the United States Postal Service to Commission Order 2792, Docket No. RM 2015-7, February 16, 2016 at 15.

whether to terminate further investigation of the Commission's directive, or, to continue the research under this restriction.

The omission of volumes collected from customers' receptacles creates the problem that the estimated coefficients, and resulting variabilities, in a top-down model will be biased. However, if that bias is not too severe, it may be possible to attempt to estimate a prototype top-down equation without the collection volumes, for the purposes of investigating its feasibility. While the coefficients and variabilities produced by a prototype top-down equation are not useable for calculating attributable costs, if the potential bias is not too severe, those coefficients would be useful for evaluating the top-down model's general performance. For example, the relative variabilities and marginal times could be compared across different types of volume to see if the top-down equation is producing operationally sensible results.

Generally, one does not have an opportunity to approximate the size of an omitted variables bias, because the data required to test for bias are unavailable. While such a situation is formally correct in this instance, there is a useful approximation that can be applied to gain a sense of the size of the bias. The approved *regular delivery time* equation includes a variable for volumes collected from customers' receptacles by city carriers. It is thus possible to investigate the impact on the estimated delivery time variabilities from omitting collection mail volumes from that equation. The two models are sufficiently similar to support drawing inferences about the potential bias in the top-down equation.

The approved delivery time equation has six coefficients that are associated with collection volume. These coefficients are the collection volume's first and second order terms, the collection volumes cross products with DPS, cased, and sequenced mail and a collection volume cross product with the number of delivery points. To investigate the omission of collection volumes from the delivery time equation, all six of these terms must be removed. The model is then re-estimated without these terms, and the results are compared with the full model to evaluate the role collection volumes play.

A first question to be investigated is whether a variable capturing the volumes collected from customer receptacles is an important explanatory variable for regular delivery time.[6] If not, the variable can be omitted from the model without concern. This question is tested by estimating the delivery equation without the collection volume terms (producing a "reduced" model) as well as the estimation of the model with those terms included (called the "complete" model) and comparing the relative explanatory powers. The estimated coefficients for the complete model were provided in the Postal Service's Report on City Carrier Street Time submitted in Docket No. RM2015-7 and the estimated coefficients for the reduced model are presented in Table 1.

[6] In FY2016, Regular delivery time was 78.6 percent of total street time, so if a variable is important for explaining variations in delivery time, it will also be important for explaining variations in total street time.

Table 1

Estimated Coefficients for the Reduced Model

Variable	Coefficient Estimates*	Heteroscedasticity Consistent t-Statistics
Intercept	-20.73286	-13.63
FSS Dummy	0.90500	2.27
DPS	-0.00003	2.09
DPS^2	4.57200	-7.75
Cased	-0.00011	3.79
$Cased^2$	3.96000	-4.58
Sequenced	-0.00008	10.67
$Sequenced^2$	11.55600	-6.67
FSS	27.28800	8.62
Delivery Points	-0.00055	25.23
Delivery $Points^2$	0.00010	-9.15
DPS*Cased	0.00019	4.97
DPS*Delivery Points	-0.00018	5.65
Cased*Delivery Points	-0.00044	-2.16
FSS*Delivery Points	0.00000	-5.86
Delivery Type	48.278	15.41
Delivery $Type^2$	-32.351	-10.04
Miles per Delivery Point	74.439	6.00
Miles per Delivery $Point^2$	-132.578	-6.46
Business Ratio	-5.899	-0.61
Business $Ratio^2$	3.189	0.22
Adjusted R^2	0.8488	
# of Obs.	3485	

** Cost driver coefficients are expressed in seconds.*

The null hypothesis that the collection volume terms have, jointly, a zero impact on delivery time is tested by examining the reduction in explanatory power that results from their omission. Specifically, the test is performed with the following F statistic:

$$F_{k-g,t-k-1} = \frac{(SSE_R - SSE_C)/(k-g)}{SSE_R/(t-k-1)}$$

In this formula SSE_R stands for the error sum of squares from the reduced model without the collection volume terms, SSE_C is the error sum of squares from the complete model without the collection volume terms included, k is the number of coefficients in the complete model, g is the number of coefficients in the restricted model, and t is the number of observations. This statistic measures the increase in the error sum of squares arising from omitting the collection volume terms adjusted for degrees of freedom. If the omission of the collection terms significantly worsens the fit of the delivery time equation, the calculated statistic will be large and the null hypothesis of no joint significance will be rejected. That is exactly what happens in this instance, as the calculated F statistic is large:

$$F_{k-g,t-k-1} = \frac{13{,}047.33}{357.90}$$

The result suggests that omitting the collection volume terms from a top-down street time model will lead to biased coefficients on the other volumes. To gain some insight into the materiality of the bias, we can calculate the variabilities and marginal times produced by the restricted model and compare them with their associated values from the complete model. The variabilities from both models are presented in Table 2.

Table 2

Estimated Variabilities From Both Models

	DPS	Cased	Sequenced	FSS	Collection
Full Specification	16.8%	7.0%	3.4%	3.0%	5.4%
Dropping Collection Volume	17.2%	8.0%	4.0%	3.5%	
Percentage Bias	2.6%	13.9%	19.3%	16.9%	

These results show that, as expected, omitting collection volumes from the equation creates a positive bias in the other variabilities. In other words, the resulting variabilities are overstated. The results show that size of the bias is not overwhelming, but it is material. Although the absolute differences between the individual variabilities are small, the variabilities themselves are relatively small, so the percentage increases in the variabilities are substantial. Table 3 shows a similar pattern holds for the marginal times; the marginal times are all higher and, with the exception of DPS, are larger by a double-digit percentage.

Table 3

Estimated Marginal Times (Seconds) From Both Models

	DPS	Cased	Sequenced	FSS	Collection
Full Specification	2.07	2.79	2.61	5.21	5.75
Dropping Collection Volume	2.15	3.23	3.15	6.17	
Percentage Bias	4.0%	15.4%	20.9%	18.4%	

On the other hand, the relative magnitudes of the various variabilities and marginal times stay about the same after the collection volumes are dropped. And they remain in the operationally feasible range. Based on this analysis, it appears that it is appropriate to continue the research on estimating a top-down model. The primary advantage of this approach is that is supports evaluation of the PTR volume data in a top-down equation prior to launching an expensive field study or MDD modification to obtain collection volume data. If the results of this research on the top-down model are deemed to be sufficiently promising, launching the required field study or MDD modification may be appropriate. If the effort fails, the Postal Service has avoided wasting resources on an unneeded study.

Before estimation of the prototype top-down model of street time commences, a number of conceptual issues associated with the top-down model need to be explored. The top-down model has the theoretical advantage of potentially providing simultaneous estimation of the street time variabilities by volume bundle or “shape,” but that advantage comes with some associated challenges. These challenges arise in both model specification issues and econometric estimation issues, and are discussed next.

B. Model Specification Issues

The first specification issue to consider is that a top-down street time model encompasses a much broader set of street time activities than previously estimated econometric models of street time. In fact, the dependent variable in a top-down street time model is *all* street time, so it includes not just regular delivery time, but also parcel/accountable delivery time, and allied time. This means the right-hand-side variables in the top-down model need to explain the variations in time required for not just regular delivery and parcel delivery, but also a variety of other street time activities such as relay, collection of volumes from street letter boxes, driving-to-and-from the routes, and other allied time.

This complexity means that correct specification of an overall top-down model must contemplate including cost driver and/or characteristic variables for all three sets of activities. Recall that the cost drivers of delivery time are the volumes delivered, by shape or bundle and the network that needs to be covered, measured by the number of delivery points. Characteristic variables control for non-volume, non-network variations in time that arise because of differences in physical delivery conditions or methods of delivery.

Previous research has shown that the cost drivers for regular delivery time include DPS mail delivered, cased mail delivered, sequenced mail delivered, FSS mail delivered, volumes of mail collected from customer receptacles and the number of delivery points in the network. The characteristic variables for regular delivery are the number of square miles in the delivery area, a measure of the delivery method (walking or driving), and the proportion of business deliveries.

The established models for parcel/accountable delivery include in-receptacle parcels, deviation parcels, accountables and the number of delivery points as cost drivers. The characteristic variables for parcel/accountable delivery include the proportions of delivery points by type and the number of delivery points. Allied time has not been modeled explicitly before, so there is no previous research to rely upon in determining model specification. Allied time is approximately 18 percent of street time.

More importantly, however, most allied activities are indirect, like driving to and from the route, and do not have identifiable cost drivers. The one exception is collection of mail from street letter boxes by letter carriers.[7] Presumably the cost drivers for this amount of time would be the volume of mail collected from street letter boxes and the number of boxes swept. The Postal Service does not have an ongoing data system that measures the daily volumes swept from street letter boxes, so that variable will also be omitted from any estimation of a top-down equation. There are data on the number of street letter boxes in each ZIP Code, recorded in the Collection Point Management System (CPMS) so that variable can be used. Additional study is required to determine if there are any other characteristic variables specific to allied activities and, if so, if there are data available to measure those characteristics.

The diversity of activities covered by a total street time equation raises the second specification issue that bears discussion. The variation in the dependent variable across heterogeneous activities implies that many different right-hand-side variables are required to properly model the variations in the dependent variable. This large number of variables, in turn, leads to an extremely high number of coefficients that need to be estimated. A full quadratic specification for a top-down model will include first order, second order, and cross product terms for nine cost driver variables and seven

[7] It is important to keep in mind that there are two separate collection activities performed on the street. The first, collection of mail from customers' receptacles, is performed primarily by regular letter carriers, the second, collection of mail from street letter boxes, is performed primarily by special purpose route carriers. That is why the proportion of regular letter carrier time devoted to collecting mail from street letter boxes is so small.

characteristic variables.[8] Such a specification would require estimation of 152 coefficients in addition to the constant. This is extremely difficult to do in a single equation.

In the established methodology, cross-product terms between the characteristic terms and the cost drivers are not included. This restriction sharply reduces the number of coefficients to be estimated and will be applied here. But even with this restriction, the list of cost drivers, along with seven characteristic variables, would still lead to the need to estimate 68 coefficients plus a constant. This is also a very large number of coefficients to be estimated in a single model, and raises a potentially high bar for successful estimation of an overall top-down equation.

C. Econometric Issues

The large number of right-hand-side variables in the top-down equation also gives rise to a potentially serious econometric problem that can occur when estimating a top-down street time model. Because the top-down model encompasses both regular delivery and parcel/accountable delivery, the list of volume cost drivers that must be included is relatively long. These volume measures tend to be correlated, and in certain cases, highly correlated, across routes or ZIP Codes. An area that receives a high

[8] For purpose of this research, we are treating the number of street letter boxes as a characteristic variable and not as a cost driver. This is done for two reasons. First, the amount of time spent by letter carriers collecting mail from street letter boxes is a tiny proportion of street time. Second, in the established specification, characteristic variables do not have cross product terms so classifying the number of street letter boxes as a characteristic variable rather than a cost driver reduces the number of coefficients to be estimated. This helps mitigate the multicollinearity problem discussed below. Finally, because this a research exercise and not the estimation of actual variabilities for use in calculating attributable costs, we can ignore the estimation of a variability for street letter box collection time.

volume of, say, DPS letters, also receives a high volume of cased mail, and a high volume of parcels. Because these volumes, across shapes, are highly correlated across ZIP Codes and through time, the right-hand-side variables in a top-down model are highly correlated. This high degree of correlation means that multicollinearity will almost certainly be a major problem for estimating a top down model, possibly precluding it from producing reliable estimates of volume variabilities.

Moreover because of the nature of the top-down equation and the nature of the data used to estimate the model, the two primary methods for dealing with multicollinearity are either generally unavailable or ineffective. First, a traditional way of dealing with multicollinearity is provided by dropping or combining variables:[9]

> The obvious remedy (and surely the most frequently used) is to drop variables suspected of causing the problem from the regression.

But in measuring city carrier attributable costs, variabilities are needed for all of the individual volume cost drivers, so this traditional solution is not readily available for the top-down model. Previous research has shown that the variabilities and marginal times for many of the different shapes or bundles are different from one another, so combining different shapes into a more aggregate bundle could produce erroneous results for products' attributable costs.

The other primary suggestion for dealing with multicollinearity is to "add data." But, in reality, this prescription is short hand for the more complete prescription of adding

[9] See, Greene, William H., Econometric Analysis, Macmillan Publishing, 1993, New York, NY at 270.

additional data that does not embody the high degree of correlation among the right hand side variables:[10]

> Because the multicollinearity problem is essentially a data problem, additional data that do not contain the multicollinearity feature could solve the problem.

In the case of estimating the top-down equation, adding more data implies either adding more ZIP Codes or adding more days of data for included ZIP Codes. But both of these methods add more data which are subject to the same correlations among types of volumes that existed in the original data set. In other words the additional data are not free from the multicollinearity feature. This is not to say that adding more data would not help at all, because additional data helps reduce the variances of the estimates, a problem created by multicollinearity:[11]

> Even adding additional data with the same multicollinearity character would help, since the larger sample size would provide some additional information, helping to reduce variances.

But because the additional volume data contains the same patterns as the original volume data, addition of data will likely have only a minimal impact on the multicollinearity and because it is so severe to start with, additional data, by itself, is

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[10] See, Kennedy, Peter, A Guide to Econometrics, Blackwell Publishing, 2008, Malden MA, at 196.

[11] Id.

unlikely to successfully mitigate the problem.[12] In other words, adding more observations may not materially reduce the correlations among the right-hand-side variables.

While there is a high correlation among volumes, by shape or bundle, across routes or ZIP Codes, there is a high disparity among the sizes of volumes, by shape, within a route or ZIP Code. The differential in volume levels is illustrated in Table 4, which presents the mean values from the July, 2016 data set.

This disparity gives rise to another problem, mainly attempting to estimate accurate variabilities for low volume shapes. For example, a typical route may involve delivery of over 2000 letters and flats per day, but will only have delivery of 1 or 2 accountables, if any. A typical amount of street time is 6.5 hours per route per day, which is 23,400 seconds. If a route gets one accountable that takes 60 seconds to deliver, accountables would cause around two--tenths of one percent (0.002) of street time. There are many non-volume reasons that street time could vary across two routes by 60 seconds (congestion, a customer greeting, and weather), particularly when the dependent variable includes allied time. This is because allied time includes "non-recurring" time which incorporates the time associated with atypical and usual street events.

This existence of this non-volume variation means that trying to accurately estimate the marginal time for an accountable or two in a top-down equation is a very difficult task. This problem also exists, to a less extreme degree, for in-receptacle and deviation parcels. If a route gets 25 deviation parcels and each one takes 40 seconds,

[12] This issue is investigated empirically later in the report when the size of the data set is doubled.

the delivery time for deviation parcels is 1,000 seconds or just 4 percent of total street time. While greater than the accountable time, this is still a relatively small proportion of total street time.

Table 4

Means from the July 2016 Data

Variable	ZIP Code Mean	Route Mean
Street Hours	136.3	6.6
DPS	28,467.1	1,373.7
Cased	7,966.6	384.4
Sequence	3,388.1	163.5
FSS	1,558.2	75.2
In-Receptacle Parcel	858.0	41.4
Deviation Parcel	554.6	26.8
Accountables	28.7	1.4
Del. Points	12,467.1	601.6
Sq Miles	40.6	2.0
# of Collection Boxes	22.4	1.1
# of Routes	20.7	
% Curb Del. Points	23.1%	
% Door Del. Points	44.2%	
% CBU Del. Points	12.6%	
% Central Del. Points	20.1%	
% Business Del. Points	8.9%	

Route means are found by dividing the ZIP Code means by the average number of routes.

D. Estimation of a Prototype Top-Down Model

As mentioned above, the prototype top-down model omits a measure of volume collected from customers' receptacles. Therefore, it has just eight cost drivers (DPS, Cased, Sequenced, FSS, In-receptacle Parcels, Deviation Parcels, Accountables, and Delivery Points). In addition, the established methodology will be used to specify the model, meaning that no cross-products involving the characteristic variables will be included. This specification is chosen because it reduces the multicollinearity problem, and thus avoids setting an unfairly high bar for the top-down model to meet. Across the three groups of activities, regular delivery time, parcel/accountable delivery time, and allied time, there are seven characteristic variables (ZIP Code square miles, proportion of business deliveries, the delivery method, the percentage of curb deliveries, the percentage of central deliveries, the percentage of cluster box deliveries, and the number of street letter boxes). This specification requires estimation of 58 coefficients, in addition to the constant.

The unit of observation used to estimate the prototype top-down model is the ZIP Code-day. This choice was made for two reasons. First, it has been the unit of observation of choice in the last two city carrier street time variability models because it reflects the level at which the Postal Service makes economic decisions about the management of carrier street time. Second, inconsistent route number hygiene across data systems makes it extremely difficult to match DOIS hours and PTR volumes at the route level. For example, suppose the data are for the eleventh carrier route in ZIP Code 12345. A typical way to identify this route in Postal Service's data systems might be 345C011. But, it might also be identified as 345C11 or 345CO11 or 345.11 or 12345C011 or 345011. This variation makes it virtually impossible to match PTR volumes to DOIS hours at the route level. With 300 ZIP Codes and 23 delivery days, there are 6,900 observations available to estimate the prototype top-down equation.

As expected, the right-hand-side variables, as a group, do a good job explaining the variation in total street time. This occurs not only because there are so many right-hand-side variables, but also because the included variables are those that have been previously proven to explain the various parts of total street time. Previous research on this type of variability equation also suggests that the residuals in the top-down equation are likely to be heteroscedastic. It is likely that the variance of daily street hours is non-constant across ZIP Code size, and could depend upon various measures of size, including the amount of volume or number of delivery points in a ZIP Code. The presence of heteroscedasticity is in fact detected by the White test, so the heteroscedasticity corrected standard errors and t-statistics will be used when making inferences about the estimated coefficients.

There is also substantial evidence that multicollinearity is a serious problem for the top-down model. First, as Table 5 reveals, the top-down equation exhibits the classic multicollinearity-induced pattern of a high R^2 statistic accompanied by many low individual t-statistics. In other words, the cost drivers, together, do a good job explaining the variation in street hours, but multicollinearity prevents accurately parsing that explanatory power to individual volume types. Nearly a third of the estimated coefficients are not statistically significant.

Table 5

Prototype Top-Down Model

July 2016 Data for 300 ZIP Codes

Variable	Coefficient	t-statistic	Variance Inflation Factor
Intercept	37.83277	17.85	0
DPS	1.197108	3.52	39.6356
DPS^2	-0.000022	-5.00	47.42876
Cased	7.668	9.29	24.80438
$Cased^2$	-0.000220	-7.85	19.45596
Sequenced	4.968	9.13	12.06174
$Sequenced^2$	-0.000085	-4.07	6.81707
FSS	23.04	16.42	15.40147
FSS^2	-0.000387	-4.06	9.50793
IR. Parcel	65.016	6.77	26.97255
IR. $Parcel^2$	-0.031896	-5.86	44.24761
DEV. Parcel	73.08	5.98	36.01872
DEV. $Parcel^2$	-0.003552	-3.86	8.09268
Accountable	116.892	0.79	19.56548
$Accountable^2$	2.267136	4.89	8.06007
Delivery Points	26.172	30.13	34.60485
Delivery $Points^2$	-0.000224	-4.34	75.258
DPS*Cased	0.000105	5.47	49.26628
DPS*Sequenced	-0.000024	-1.46	20.58635
DPS*FSS	-0.000036	-1.21	25.67675
DPS*IR. Parcel	0.000169	0.63	83.94999
DPS*DEV. Parcel	-0.000368	-1.74	39.11106
DPS*Accountable	-0.007740	-2.14	39.73735
DPS*Delivery Points	0.000141	4.89	128.28575
Cased*Sequenced	0.000026	0.82	8.424
Cased*FSS	0.000170	2.70	8.32404
Cased*IR. Parcel	-0.001577	-2.42	44.22488
Cased*DEV. Parcel	0.001597	2.89	25.52409
Cased*Accountable	-0.028872	-2.97	19.75431
Cased*Delivery Points	0.000017	0.26	60.12762
Sequenced*FSS	-0.000020	-0.34	3.04217
Sequenced*IR. Parcel	-0.000762	-1.59	15.12552
Sequenced*DEV. Parcel	-0.000662	-1.48	9.8188
Sequenced*Accountable	0.022320	2.53	5.2037
Sequenced*Delivery Points	0.000067	1.48	27.52116
FSS*IR. Parcel	-0.001377	-1.23	28.90775
FSS*DEV. Parcel	0.005796	4.56	13.54995
FSS*Accountable	-0.027972	-1.70	8.67797
FSS*Delivery Points	-0.000537	-5.25	27.77699
IR. Parcel* DEV. Parcel	-0.008316	-1.06	48.05764
IR. Parcel*Accountable	0.381024	3.26	22.85057
IR. Parcel*Delivery Points	0.002270	3.24	69.69456
DEV. Parcel*Accountable	0.000091	0.00	20.7631
DEV. Parcel*Delivery Points	-0.002540	-3.00	61.25793
Accountable*Delivery Points	-0.012780	-0.97	40.70953
Business Ratio	2.68216	0.30	5.84474
Business $Ratio^2$	41.92127	2.71	5.05028
Square Miles	-0.03596	-7.71	5.75513
Square $Miles^2$	0.00002721	5.97	4.96968
Delivery Type	14.93361	4.52	23.95644
Delivery $Type^2$	-26.87459	-8.32	22.87859
# of Street Collection Boxes	0.23757	5.60	10.96217
# of Street Collection $Boxes^2$	0.00053772	1.40	8.96424
% Curb Delivieries	-51.0924	-11.11	16.11928
% Curb $Delivieries^2$	-9.54524	-1.57	13.68576
% CBU Delivieries	-172.38237	-23.59	10.96728
% CBU Delivieries2	161.62571	11.47	9.23035
% Central Delivieries	-50.5461	-9.90	12.11952
% Central Delivieries2	-74.4617	-10.20	11.87029
R^2	0.9067		
# of Observations	6900		
Condition Index	110.57		

Volume and delivery point coefficients are expressed in seconds to facilitate interpretation

More formal measures of the presence of multicollinearity also indicate that it is a serious problem. Table 5 presents the variance inflation factors (VIFs) for each of the estimated coefficients. The VIF measures the degree to which multicollinearity is increasing a coefficient's estimated standard error. This is demonstrated by the following formula:

$$\sigma^2_{\beta_i} = \frac{\sigma^2}{x_i' x_i} VIF_i \,.$$

The VIF also reflects the correlation between any right-hand-side variable and all of the other right-hand-side variables. Its computational formula is given by:

$$VIF_i = \frac{1}{1 - R_i^2}.$$

The R_i^2 term is the multiple correlation coefficient of x_i with the remaining right-hand-side variables. As that correlation rises, so does the VIF. Unfortunately, the VIF does not have a critical value or "cutoff" value for determining when multicollinearity is a problem. A value of 10 is sometimes suggested because that is associated with an R^2 value of 90 percent in the auxiliary regression of a given variable on the other variables in the equation.

Table 5 shows that 42 of the 58 estimated coefficients (72.4 percent) have VIFs greater than 10, suggesting a serious multicollinearity problem. Table 5 also presents the condition index for the top-down equation. The Condition Index reflects the ratio of the largest eigenvalue of the matrix of right-hand-side variables to the smallest eigenvalue of that matrix. A small eigenvalue is suggestive of strong collinearity among the right-hand-side variables, so a large value for the Condition Index is evidence of multicollinearity because it reveals that there are some very small eigenvalues. Belsley, Kuh, and Welsch indicate that a Condition Index greater than 30 indicates moderate dependencies among the right-hand-side variables, and a value approaching 100 indicates strong dependencies.[13] The Condition Index for the top-down equation is 110.67, indicating that the equation suffers from serious multicollinearity, even without the inclusion of the volume of mail collected from customers' receptacles.

Some multicollinearity should be expected in a quadratic equation with so many right-hand-side variables because of the natural correlation between first and second order terms, but the degree of multicollinearity in the top-down equation goes well beyond that expected amount. It arises because of the strong correlation, both across ZIP Code and across days, among the various volume measures. There is a significant correlation across all of the cost driver variables, but certain combinations are

Table 6

Corrrelations Among Cost Driver Variables in Prototype Top-Down Model

	DPS	Cased	Sequence	FSS	IR Parcel	DEV Parcel	Acct.	Delivery Points
DPS	1	0.62936	0.20304	0.42956	0.6739	0.42158	0.52828	0.73273
		<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Cased	0.62936	1	0.17768	0.08746	0.51606	0.34294	0.37932	0.58955
	<.0001		<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Sequence	0.20304	0.17768	1	0.15911	0.16306	0.14393	0.01291	0.26036
	<.0001	<.0001		<.0001	<.0001	<.0001	0.2835	<.0001
FSS	0.42956	0.08746	0.15911	1	0.38279	0.16683	0.22128	0.23402
	<.0001	<.0001	<.0001		<.0001	<.0001	<.0001	<.0001
IR Parcel	0.6739	0.51606	0.16306	0.38279	1	0.50555	0.38021	0.61483
	<.0001	<.0001	<.0001	<.0001		<.0001	<.0001	<.0001
DEV Parcel	0.42158	0.34294	0.14393	0.16683	0.50555	1	0.33779	0.39914
	<.0001	<.0001	<.0001	<.0001	<.0001		<.0001	<.0001
Acct.	0.52828	0.37932	0.01291	0.22128	0.38021	0.33779	1	0.42038
	<.0001	<.0001	0.2835	<.0001	<.0001	<.0001		<.0001
Delivery Points	0.73273	0.58955	0.26036	0.23402	0.61483	0.39914	0.42038	1
	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	

[13] See, Belsley, David, Kuh, Edwin, and Welsch, Roy, Regression Diagnostics: Identifying Influential Data and Sources of Collinearity, John Wiley and Sons, 2004.

particularly correlated. Those combinations are highlighted in Table 6, which shows the correlations across the 6,900 observations in the July data set.

Both DPS letters and in-receptacle parcels have high (> 30 percent) correlations with six of the other seven volumes. Cased mail, deviation parcels, and delivery points have high correlations with five of the other six volumes. In sum, these very high correlations make accurately identifying coefficients (and thus variabilities) on individual volume types very difficult.

This difficulty in estimating individual volume effects may be reflected in the elasticities and marginal times produced by the prototype top-down model, because they are based upon the estimated coefficients. Table 7 presents both the elasticities and the marginal times for all of the included volume measures. Recall that the omission of volumes collected from customers' receptacles likely leads to an upward bias in both estimated elasticities and marginal times.

Table 7

Elasticities and Marginal Times from A Prototype Top-Down Model of Street Time

Volume Type	Marginal Time	Elasticity
DPS	2.15	11.5%
Cased	6.40	9.6%
Sequenced	4.31	2.7%
FSS	16.62	4.9%
IR Parcel	32.44	5.2%
Dev. Parcel	39.33	4.1%
Accountable	-3.11	-0.02%

Because they are multiplied against different, and different sized, cost pools, the elasticities in the established methodology and the elasticities derived from the top-down model are not directly comparable. However, the overall variability of street time from applying the established methodology was 36.3 percent in FY 2016 and the sum of the elasticities from the prototype top-down model is 38.0 percent. These numbers are comparable because both are multiplied by total street time.

The marginal times from the established methodology and the prototype top-down model are not strictly comparable because the top-down times would include any marginal street support time which is not included in the delivery-model marginal times in the established methodology. Nevertheless, because of the relatively small size of street support, an adjustment can be made to construct marginal times that are applicable for order-of magnitude comparisons.[14]

Two results for the prototype top-down model immediately jump out of Table 8: the fact that the marginal time for accountables is negative, and the fact that the marginal time for FSS is unrealistically large. The negative accountable marginal time is a manifestation of the differential-size problem discussed above. There is just too little variation in accountable delivery time relative to the time variations across routes and ZIP Codes to accurately measure an accountable variability and marginal time in a top-down model. The extreme FSS marginal time arises from a different problem.

[14] In FY 2016, volume variable street support was 10.84 percent of volume variable deliveries activities ($439.3 million over $4.05 billion). The original established model marginal times were multiplied by 1.1084 to produces the adjusted marginal times.

Table 8

Marginal Times From the Established Methodology and the Prototype Top-Down Model Based Upon July 2016 Data

Type of Mail	Established Models	Adjusted Established Models	Prototype Top-Down
DPS Piece	2.07	2.29	2.15
Cased Mail Piece	2.79	3.09	6.40
Sequenced Piece	2.61	2.89	4.31
FSS Piece	5.21	5.77	16.62
Collection Piece	5.75	6.37	n.a.
In Receptacle Package	17.98	19.93	32.44
Deviation Package	19.71	21.85	39.33
Accountable	69.28	76.79	-3.11

As discussed in Docket No. RM2015-7, FSS Zones differ from non-FSS zones for reasons other than the existence of FSS processing:[15]

> This difference raises the possibility that FSS ZIP Codes are different from non-FSS ZIP Codes for reasons other than the presence of FSS mail. If so, then the coefficients on the FSS variables could be picking up something other than its pure cost-causing effect and its marginal time could be overstated.

In the established methodology, a dummy variable was included in the delivery time equation to control for these differences, because there was an insufficient amount of data to estimate separate delivery time equations for FSS and non-FSS zones. One of the advantages of using operational data is that it permits constructing larger data

[15] See, Report on the City Carrier Street Time Study, USPS-RM2015-7/1, Docket No. RM2015-1, at 76.

sets and the July 2016 data sets used to estimate the prototype top-down model is much larger (at 6,900 observations) than the one used to estimate the established delivery time model (at 3,485). This larger data set permits estimating separate equations for the two types of zones as there are 1,990 observations for FSS zones and 4,910 observations for the non-FSS zones.

Table 9 presents the results of estimating the prototype top-down model for FSS zones. The DPS, cased, sequenced, FSS and deviation parcel volumes all have the expected coefficient pattern of a positive first order term and a negative second order term. But both in-receptacle parcels and accountables have that pattern reversed, with both variables have a negative first order term and a positive second order term. Such a pattern is counter-intuitive. This reversal of coefficient signs may reflect parameter instability caused by multicollinearity, which appears to be a bit more severe for the FSS equation. The number of coefficients which are not statistically significantly is higher for the FSS equation than it is for the overall equation, with 27, or 46.6 percent, not achieving that standard. In addition, the Condition Index is 142.42 which is well above the value of 110.57 for the top-down equation estimated on all observations. To a degree, this result is not surprising, as the number of observations is much smaller for estimating the FSS-only equation, but it may also reflect a tighter correlation among right-hand-side variables in FSS zones.

Table 9

Prototype Top-Down Model

July 2016 Data for FSS ZIP Codes

Variable	Coefficient	t-statistic	Variance Inflation Factor
Intercept	38.81798	8.59	0
DPS	2.343888	3.48	40.99543
DPS^2	-0.000023	-2.03	80.37002
Cased	9.972	4.69	29.17974
Cased^2	-0.000217	-5.51	14.41425
Sequenced	0.81666	0.82	16.94329
Sequenced^2	-0.000056	-1.52	8.23725
FSS	7.812	3.88	20.90398
FSS^2	-0.000037	-0.28	21.75586
IR. Parcel	-25.452	-1.39	39.1232
IR. Parcel^2	0.018072	2.40	48.61788
DEV. Parcel	119.088	4.80	32.52197
DEV. Parcel^2	-0.074952	-4.39	44.93056
Accountable	-862.56	-3.01	29.1889
Accountable^2	1.178532	1.37	16.06472
Delivery Points	34.812	19.60	47.39062
Delivery Points^2	-0.000538	-5.62	103.5581
DPS*Cased	0.000121	3.06	60.75741
DPS*Sequenced	-0.000022	-0.89	21.63532
DPS*FSS	-0.000038	-0.65	68.854
DPS*IR. Parcel	-0.000172	-0.44	108.74266
DPS*DEV. Parcel	-0.000106	-0.19	64.45531
DPS*Accountable	-0.005724	-1.14	53.17918
DPS*Delivery Points	0.000087	1.70	152.54704
Cased*Sequenced	-0.000100	-1.89	7.75227
Cased*FSS	-0.000491	-4.27	26.4742
Cased*IR. Parcel	-0.003105	-2.56	61.23904
Cased*DEV. Parcel	0.001450	0.97	35.15072
Cased*Accountable	-0.057384	-4.06	23.91773
Cased*Delivery Points	0.000409	3.67	64.76159
Sequenced*FSS	-0.000151	-1.96	6.84514
Sequenced*IR. Parcel	0.000808	1.40	13.14509
Sequenced*DEV. Parcel	0.003124	3.91	9.99859
Sequenced*Accountable	-0.002532	-0.26	5.60284
Sequenced*Delivery Points	0.000102	1.69	26.27519
FSS*IR. Parcel	0.002064	1.22	53.25959
FSS*DEV. Parcel	-0.001216	-0.55	30.53624
FSS*Accountable	0.057096	2.48	24.06548
FSS*Delivery Points	0.000055	0.35	50.7388
IR. Parcel* DEV. Parcel	0.009756	0.59	53.25064
IR. Parcel*Accountable	0.161748	1.05	29.85721
IR. Parcel*Delivery Points	-0.001843	-2.09	66.95497
DEV. Parcel*Accountable	0.396720	2.10	36.05291
DEV. Parcel*Delivery Points	0.001140	0.71	79.73974
Accountable*Delivery Points	0.018612	0.88	71.88106
Business Ratio	188.4688	4.30	17.82267
Business Ratio^2	-444.45836	-2.52	16.69416
Square Miles	-0.06015	-0.52	11.90861
Square Miles^2	0.00044139	0.46	9.04665
Delivery Type	51.62764	7.86	26.96967
Delivery Type^2	-62.42106	-9.88	26.14058
# of Street Collection Boxes	0.10477	1.43	16.09395
# of Street Collection Boxes^2	0.00216	2.93	16.32634
% Curb Delivieries	-75.60926	-8.15	24.71311
% Curb Delivieries^2	30.17365	2.78	19.72115
% CBU Delivieries	-222.96422	-16.16	16.172
% CBU Delivieries2	209.34252	8.81	11.9319
% Central Delivieries	-49.4402	-5.24	16.95691
% Central Delivieries2	-104.20979	-8.82	18.24751
R^2	0.9058		
# of Observations	1990		
Condition Index	142.42		

Volume and delivery point coefficients are expressed in seconds to facilitate interpretation

Estimating a top-down model for non-FSS zones requires modifying the specification of the equation. Because no FSS mail is delivered in these zones, the first and second order terms in FSS, along with all cross-product terms including FSS, must be dropped from the equation. This reduces the number of coefficients to be estimated from 58 to 49. Otherwise the specification stays the same.

The estimated coefficients for the top-down equation estimated for non-FSS zones are presented in Table 10. All of the cost drivers have the expected sign pattern of a positive first order term and a negative second order term. In addition, a lower proportion of coefficients, 22.5 percent (11/49), are statistically insignificant than in the previously estimated top-down equations. The most likely reflects the reduction in the number of coefficients to be estimated. Multicollinearity remains a problem for the non-FSS zone equation, nonetheless, as 40 of 49 estimated coefficients (81.6 percent) have a VIF greater than 10 and the condition index remains above 100.

To determine the implications of separately estimating top-down models for FSS and non-FSS zones, for calculating elasticities and marginal times, the results of the two equations must be combined. The combination is required because a single elasticity or marginal time for each volume type must be applied to total accrued cost to form the volume variable cost pools.

By construction, total street time (ST) is the sum of street time for FSS zones (ST_F) and the street time for non-FSS zones (ST_N). Each of the two street time subsets are determined by the volumes in their own zones. Mathematically, this is represented as:

$$ST = ST_F(v_{F1}, v_{F2}, v_{F3}, \ldots v_{F1},) + ST_N(v_{N1}, v_{N2}, v_{N3}, \ldots v_{N1}).$$

Table 10

Prototype Top-Down Model

July 2016 Data for non-FSS ZIP Codes

Variable	Coefficient	t-statistic	Variance Inflation Factor
Intercept	37.59361	15.64	0
DPS	1.11366	2.79	39.60246
DPS^2	-0.000022	-4.53	38.98337
Cased	10.44	10.47	28.71017
$Cased^2$	-0.000167	-3.44	33.98821
Sequenced	5.292	7.42	11.5963
$Sequenced^2$	-0.000093	-2.98	6.70866
IR. Parcel	34.02	2.28	28.90793
IR. $Parcel^2$	-0.035208	-3.91	53.54339
DEV. Parcel	98.208	4.66	47.6795
DEV. $Parcel^2$	-0.004824	-2.97	11.41714
Accountable	258.732	1.38	19.76131
$Accountable^2$	3.019788	4.72	9.65995
Delivery Points	24.192	23.12	34.32388
Delivery $Points^2$	-0.000148	-2.28	73.76783
DPS*Cased	0.000182	7.34	59.25373
DPS*Sequenced	-0.000027	-1.18	22.68557
DPS*IR. Parcel	-0.000213	-0.61	77.94461
DPS*DEV. Parcel	-0.000719	-2.89	44.125
DPS*Accountable	-0.009324	-2.01	37.0725
DPS*Delivery Points	0.000125	3.49	127.71163
Cased*Sequenced	0.000072	1.48	11.5255
Cased*IR. Parcel	-0.003340	-3.60	58.12702
Cased*DEV. Parcel	0.003130	3.42	34.40171
Cased*Accountable	-0.060444	-4.26	26.68699
Cased*Delivery Points	-0.000331	-3.82	77.70921
Sequenced*IR. Parcel	-0.002004	-2.87	18.99058
Sequenced*DEV. Parcel	-0.001266	-1.89	12.87546
Sequenced*Accountable	0.028224	2.21	5.95614
Sequenced*Delivery Points	0.000125	2.01	34.03972
IR. Parcel* DEV. Parcel	-0.006912	-0.62	66.54129
IR. Parcel*Accountable	0.193752	0.93	39.38852
IR. Parcel*Delivery Points	0.007596	5.89	91.95503
DEV. Parcel*Accountable	0.236664	1.20	35.32962
DEV. Parcel*Delivery Points	-0.004788	-3.04	81.96484
Accountable*Delivery Points	0.013572	0.73	39.08988
Business Ratio	-19.56405	-2.02	6.82735
Business $Ratio^2$	64.41336	4.01	5.83388
Square Miles	-0.01742	-3.79	6.31265
Square $Miles^2$	0.00001031	2.30	5.39086
Delivery Type	-0.51594	-0.13	25.33455
Delivery $Type^2$	-10.61338	-2.85	23.54436
# of Street Collection Boxes	0.27468	5.07	10.58767
# of Street Collection $Boxes^2$	-0.00061734	-1.24	8.37049
% Curb Delivieries	-36.25885	-6.74	16.13771
% Curb $Delivieries^2$	-30.38847	-4.14	13.49506
% CBU Delivieries	-171.80553	-18.97	10.43723
% CBU Delivieries2	182.03729	9.22	9.05662
% Central Delivieries	-52.54704	-8.66	11.92419
% Central Delivieries2	-65.11248	-7.27	11.19839
R^2	0.9085		
# of Observations	4910		
Condition Index	104.74		

Volume and delivery point coefficients are expressed in seconds to facilitate interpretation

The marginal street time with respect to volume type 1 (e.g. city carrier delivered DPS letters) is the first derivative of street time with respect to that volume.

$$\frac{\partial ST}{\partial V_1} = \frac{\partial ST_F}{\partial V_{F1}} \frac{\partial V_{F1}}{\partial V_1} + \frac{\partial ST_N}{\partial V_{N1}} \frac{\partial V_{N1}}{\partial V_1}.$$

But, marginal changes in the amount of city carrier delivered volume type 1 do not change the split of that type of volume between FSS and non-FSS zones. In other words, the growth or decline rate in the two zonal volumes equals the growth or decline rate in the overall volume, in response to a marginal change in volume:

$$\frac{\partial V_{Fi}}{V_{Fi}} = \frac{\partial V_{Ni}}{V_{Ni}} = \frac{\partial V_i}{V_i}.$$

This means that the overall marginal time is just the volume-weighted average of the two individual marginal times:

$$\frac{\partial ST}{\partial V_1} = \frac{\partial ST_F}{\partial V_{F1}}\left(\frac{V_{F1}}{V_1}\right) + \frac{\partial ST_N}{\partial V_{N1}}\left(\frac{V_{N1}}{V_1}\right).$$

With some algebra, one can show this is consistent with the established methodology for calculating the overall elasticity of a cost pool made up of a complete set of cost sub-pools. That methodology specifies that the overall elasticity is the cost or time weighted value of the individual elasticities:

$$\varepsilon_{ST,V_1} = \varepsilon_{ST_F,V_1}\left(\frac{ST_F}{ST}\right) + \varepsilon_{ST_N,V_1}\left(\frac{ST_N}{ST}\right).$$

The marginal times arising from separately estimating top-down equations for FSS and non-FSS zones are presented in Table 11. Splitting the zones by the presence of FSS mail was successful in estimating a more reasonable marginal time for FSS mail. The combined marginal time from the split regressions is 5.9 seconds, instead of the 16.62 seconds produced by the single top-down model.

Table 11

Marginal Times Arising from Separately Estimating Top Down Equations by FSS and non-FSS Zones

Volume Shape	FSS ZONES	Non-FSS Zones	Combined
DPS	2.0	2.1	2.1
Cased	9.1	6.0	6.8
Sequenced	2.2	4.8	3.7
FSS	5.9		5.9
In-Receptacle Parcel	-12.2	34.5	17.1
Deviation Parcel	76.5	41.2	53.3
Accountable	-410.2	187.3	-22.9

Splitting the zones did not improve the accountable marginal time, as it is still negative, but it did have a material impact on the parcel marginal times. The in-receptacle parcel marginal time is much smaller than its single-equation counterpart, falling form 32.4 seconds to 17.1 seconds. At the same time the marginal time for deviation parcels rose considerably from 39.3 seconds to 53.3 seconds. This type of instability is characteristic of multicollinearity, and raises the question of whether the top-down model can accurately estimate separate elasticities and marginal times for in-receptacle and deviation parcels. The multicollinearity problem, moreover, is compounded for parcels because of their relatively small volumes.

An alternative possibility is to estimate top-down models including a single, unified parcel variable. This approach would provide just one elasticity and marginal time for parcels, that would be applied to both in-receptacle and deviation parcels.

To investigate this possibility, both the FSS and non-FSS top-down equations were re-estimated, after incorporating a single parcel variable that is the sum of the in-receptacle and deviation parcels. This unification of the parcel variable reduced the number of coefficients to be estimated in the FSS zone model to 48, and in the non-FSS model to 41. The complete set of regression results for the unified parcel model is provided in USPS-PI2017-1/2, but Table12 presents the resulting marginal times.

Table 12

Marginal Times Arising from Separately Estimating Top Down Equations by FSS and non-FSS Zones with a Unified Parcel Variable

Volume Shape	FSS ZONES	Non-FSS Zones	Combined
DPS	1.9	2.2	2.1
Cased	9.2	5.9	6.8
Sequenced	2.3	4.7	3.6
FSS	6.2		6.2
Parcel	21.7	28.4	26
Acct	-339	264	51.9

Combining the in-receptacle and deviation parcels into a single variable appears to have stabilized the estimation of parcel marginal time across FSS and non-FSS zones. No longer is there a negative marginal time in FSS zones and the combined marginal time is in between the individual marginal times estimated for in-receptacle and deviation parcels. However, the ability to identify separate costs for the two types of parcels is lost.

One additional check on the top-down model was performed. Data were originally obtained from DOIS and PTR for July 2016 because the Postal Service had confidence that the PTR reporting mechanisms were firmly in place by that time. However, to investigate the potential impact of using a specific-month's data to estimate the top-down model, the Postal Service also collected data for September 2016 and combined it with the July 2016 data in order to re-estimate the top-down model on a larger data set. Because September is a higher volume month that July, this analysis can provide insight into the impact on the estimated variabilities and marginal times arising from adding another month's data. In addition, doubling the amount of data used to estimate the top-down equation can provide information about whether the multicollinearity problem can be mitigated by adding additional data points.[16]

Table 13 presents the mean values for the combined July and September data set. As expected, the volume means are all higher, reflecting the fact that volume levels in September are above those for July. The variables that depend solely upon cross-sectional variation, the characteristic variables, have not change in their mean values.

[16] Because of the Labor Day holiday, the September data set has 6,900 observations just like the July data set, leading to a total of 13,800 observations used to estimate the top-down model.

Table 13

Means from the July and September 2016 Data

Variable	ZIP Code Mean	Route Mean
Street Hours	137.4	6.6
DPS	29,174.7	1,407.4
Cased	8,614.9	415.6
Sequence	3,608.4	174.1
FSS	1,755.7	84.7
In-Receptacle Parcel	888.6	42.9
Deviation Parcel	579.8	28.0
Accountables	29.2	1.4
Del. Points	12,470.0	601.5
Sq Miles	40.6	2.0
# of Collection Boxes	22.4	1.1
# of Routes	20.7	
% Curb Del. Points	23.1%	
% Door Del. Points	44.2%	
% CBU Del. Points	12.6%	
% Central Del. Points	20.1%	
% Business Del. Points	8.9%	

Route means are found by dividing the ZIP Code means by the average number of routes.

The results of estimating the top-down model on all 13,800 observations are presented in Table 14. A comparison of those results with those presented in Table 5, based upon just the July data, show that the two estimated models are quite similar. All of the estimated coefficients have the same signs and are of similar orders of magnitude. This means that the elasticities and marginal times are thus also similar.

Table 14

Prototype Top-Down Model

July and September 2016 Data for 300 ZIP Codes

Variable	Coefficient	t-statistic	Variance Inflation Factor
Intercept	35.80612	23.22	0
DPS	1.442916	5.85	40.42266
DPS^2	-0.000017	-4.12	45.35852
Cased	6.732	11.44	24.09336
Cased^2	-0.000141	-7.28	16.25439
Sequenced	5.184	13.80	12.42209
Sequenced^2	-0.000068	-7.86	4.78062
FSS	20.772	22.78	15.68356
FSS^2	-0.000382	-7.95	9.19044
IR. Parcel	52.632	7.32	26.59973
IR. Parcel^2	-0.024912	-4.47	43.77712
DEV. Parcel	72.468	8.00	29.09483
DEV. Parcel^2	-0.004176	-4.47	5.77892
Accountable	82.944	0.71	18.82029
Accountable^2	1.545732	3.70	6.5669
Delivery Points	26.964	42.11	33.85858
Delivery Points^2	-0.000240	-6.29	74.29899
DPS*Cased	0.000064	4.59	44.22261
DPS*Sequenced	-0.000005	-0.41	20.06642
DPS*FSS	-0.000023	-1.18	25.61185
DPS*IR. Parcel	0.000349	1.69	89.46012
DPS*DEV. Parcel	-0.000611	-2.84	45.45258
DPS*Accountable	-0.002738	-0.95	41.12768
DPS*Delivery Points	0.000120	5.43	117.5993
Cased*Sequenced	0.000002	0.08	8.59649
Cased*FSS	0.000115	2.60	9.53261
Cased*IR. Parcel	-0.001900	-4.29	42.04176
Cased*DEV. Parcel	0.001469	3.12	24.55188
Cased*Accountable	-0.019188	-2.88	17.76545
Cased*Delivery Points	0.000055	1.17	56.67431
Sequenced*FSS	-0.000036	-1.02	2.88114
Sequenced*IR. Parcel	-0.001056	-3.50	15.7415
Sequenced*DEV. Parcel	-0.000389	-1.33	9.61336
Sequenced*Accountable	0.015048	2.00	5.05222
Sequenced*Delivery Points	0.000019	0.67	25.10901
FSS*IR. Parcel	-0.001048	-1.50	27.71113
FSS*DEV. Parcel	0.004716	5.45	13.75894
FSS*Accountable	-0.025128	-2.10	8.61368
FSS*Delivery Points	-0.000464	-7.08	25.3936
IR. Parcel* DEV. Parcel	-0.007200	-1.04	47.26023
IR. Parcel*Accountable	0.197676	2.38	21.62839
IR. Parcel*Delivery Points	0.002486	4.88	66.77626
DEV. Parcel*Accountable	0.152928	1.80	14.77075
DEV. Parcel*Delivery Points	-0.002332	-3.59	56.65003
Accountable*Delivery Points	-0.021492	-2.29	31.68016
Business Ratio	5.24364	0.80	5.84627
Business Ratio^2	48.40602	4.26	4.99391
Square Miles	-0.03275	-9.97	5.78315
Square Miles^2	0.00002392	7.42	4.98718
Delivery Type	16.35522	6.99	24.0162
Delivery Type^2	-27.75491	-12.20	22.927
# of Street Collection Boxes	0.25265	8.27	10.98395
# of Street Collection Boxes^2	0.00005475	0.19	8.95034
% Curb Delivieries	-52.34915	-16.08	16.05532
% Curb Delivieries^2	-5.84417	-1.37	13.62591
% CBU Delivieries	-172.31935	-32.90	10.97044
% CBU Delivieries2	165.17802	16.59	9.25234
% Central Delivieries	-47.5949	-12.75	12.08239
% Central Delivieries2	-76.33026	-14.06	11.56145
R^2	0.9065		
# of Observations	13800		
Condition Index	108.23		

Volume and delivery point coefficients are expressed in seconds to facilitate interpretation

There is also little difference in the degree of multicollinearity in the two equations. The top-down model based upon just July data had a Condition Index of 110.6 and the Condition Index for the version of the model based upon both months is 108.2. The July-only version of the model had 42 of the 58 coefficients with VIFs greater than 10 and the July and September version of the model has the same number. Multicollinearity does not abate from doubling the data set, because the correlations among the volume variables is just as high using two months of data as it was with just one month.

Because of the similarities to the July-only model in the estimated coefficients, the July and September model also suffers from an extreme marginal time value for FSS mail. It is thus appropriate to estimate separate top-down models for FSS and non-FSS zones for the expanded data sets. The complete estimation results of this exercise are provided in USPS-PI2017-1/2, but the marginal times from the top-down model estimated on the extended data set, along with those based upon the July-only data set, are presented in Table 15. Results for both the split parcel variable and the unified parcel variable are presented.

The results show little difference between the July-only version of the top-down model and the July and September version. The estimated marginal times are quite similar, with some of the July and September times being a bit above and some being a bit below the July-only times.[17]

[17] The exception is the marginal time for accountables which varies quite a bit. This is to be expected as the coefficients for accountable volume are not reliably estimated in any of the versions.

Table 15

Marginal Times Arising from Adding September's Data

	Split Parcel		Unified Parcel	
Volume Type	**July**	**July & Sept.**	**July**	**July & Sept.**
DPS	2.1	2.2	2.1	2.2
Cased	6.8	6.2	6.8	6.1
Sequenced	3.7	3.5	3.6	3.5
FSS	5.9	5.2	6.2	5.4
In-Receptacle	17.1	17.4		
Deviation Parcel	53.3	50.5		
Unified Parcel			26.0	27.5
Accountable	-22.9	-52.0	51.9	0.3

Lastly, the overall impact of doubling the size of the data set on the presence of multicollinearity can be assessed. Table 16 includes the Condition Indices for the various versions of the prototype top-down model that were estimated, once on just July data, and once on both July and September data. This table provides insight into the effectiveness of the two classic corrections for multicollinearity discussed above. The first correction is to drop and/or combine variables to reduce the numbers of coefficients to be estimated. For the prototype top-down model, the numbers of coefficients to be estimated were reduced by combining the in-receptacle and deviation parcel variables into a single parcel variable. One can assess the impact on multicollinearity by comparing the unified parcel models with their corresponding split parcel models. For example, compare the Condition Indices in the first row and the fourth row. This comparison demonstrates the expected reduction in the Condition Index from reducing the number of coefficients to be estimated, but the reduction is quite small relative to the size of the indices and leaves it near 100. Even after the reduction in coefficients, the condition indices continue to signal severe multicollinearity.

The second classic correction for multicollinearity is to add more data. The impact of that approach can be assessed for the prototype top-down model by comparing the Condition Indices for each version of the model estimated on just the July data with the same version estimated on both the July and September data. The reductions in the Condition Indices are quite small, in fact smaller than the reductions from unifying the parcel variable. Doubling of the size of the data set has an extremely small impact on multicollinearity. This reflects the fact that the delivered volume variables are just as correlated in the September data as they are in the July data.

Table 16

Condition Indices for Different Numbers of Coefficients and Observations

		July Data		July & Sept. Data	
Model Version	**# of Estimated Coefficients**	**# of Observations**	**Condition Index**	**# of Observations**	**Condition Index**
All Zones / Split Parcel	58	6,900	110.6	13,800	108.2
FSS Zones /Split Parcel	58	1,990	142.4	3,950	134.9
Non FSS Zones / Split Parcel	49	4,910	104.8	9,850	104.6
All Zones / Unified Parcel	49	6,900	99.0	13,800	97.6
FSS Zones /Unified Parcel	49	1,990	130.2	3,950	127.0
Non FSS Zones / Unified Parcel	41	4,910	91.9	9,850	92.2

E. Conclusions

The Postal Service has performed the research necessary for evaluating estimation of a top-down model of city carrier street time. It investigated its operating data systems in order to try to obtain the data necessary to estimate the model. It then used available data to estimate a prototype top-down model that sheds some insight into that model's ability to reliably estimate the coefficients necessary to calculate the city carrier street time elasticities. A number of lessons were learned in doing this research.

First, the Postal Service does not collect data on the volume of mail collected from customers' receptacles on an ongoing basis. Thus, no operational data system can provide this information, and there is not a reliable proxy available. The omission of this variable causes a bias in the other estimated elasticities and that bias is likely material, but not overwhelming. Estimation of a complete top-down model will require either a special field study or a special application of the carriers' MDDs to obtain the collection volume data.

Second, it appears that the FSS volume variable captures differences between FSS and non-FSS zones other than the impact of the volume itself. This creates an upward bias in the estimated elasticity and marginal time for FSS volume. In the established methodology, this effect was controlled by inclusion of an FSS dummy variable, but there is sufficient operational data to permit estimation of separate top-down street time models for FSS and non-FSS zones.

Third, estimation of the top-down model for city carrier street time suffers from serious, potentially disqualifying, multicollinearity. A number of different indicators suggest a high degree of multicollinearity exists, undermining the equation's ability to produce reliable estimates of the effects of different types of volume on street time. Traditional remedies for multicollinearity, like dropping variables or adding additional observations, do not appear to provide a solution for multicollinearity in the top-down equation. One symptom of multicollinearity is that estimates are not stable over reasonable data divisions. This appears to be the case for the estimated parcel elasticities and marginal times, which are unstable across estimates for FSS and non-FSS zones.

Fourth, the top-down model was not able to provide reliable estimates of an accountable elasticity and marginal time. Accountable volumes are so small relative to letter and flat volumes, that non-volume variations in total street time appear to swamp and variation created by changes in the volume of accountables.